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MISSION TO MARS

I began my internship at the Jet Propulsion Laboratory on June 21, 1999. And as I near the completion of my first internship tour here, I would like to reflect upon what I have learned, and more importantly, what I will bring back with me as I return to school. I feel very fortunate that I have had this opportunity. At an academic institution such as the University of Illinois, it is not all too difficult for one to find a job or internship with an engineering background. Employers are plentiful, as are the employees. On the other hand, JPL offers an experience unlike any other job, because it is the only functioning organization in the world to specialize in robotics and space exploration. In light of this, one must look at the problems encountered here differently from other fields. Answers are not readily available; each mission has a new purpose and novel technology incorporated in it. It is not just a modification of “last year’s model.” In order to understand the nature of the work and technology and ultimately find answers, I had to see the problem in two ways: 1) delve into the technical aspects, and 2) see laterally, or in other words, see the “bigger picture.”

The technology I dealt with was thermal control hardware for Mars Rover missions, specifically loop heat pipes. This system allows very robust thermal control without the use of huge power inputs, which is precisely what is needed for a long-duration mission to another planet. With the use of only a few batteries and heaters, most of the heat source came from Radioisotope Heating Units (RHUs) that were left over from previous missions. Thermal control was achieved by amazingly efficient heat transfer with ammonia flowing through the heat pipe with a valve directing the flow of heat either back into the system of electronics or out to a radiator. Also incorporated was a phase change module that would store heat through the natural process of phase change of dodecane.

I learned very quickly that JPL deals with such sophisticated and complex systems all the time, and in order to truly comprehend the intricacies of them, one must dig deeply into the problem. My internship here lasted over six months, and thus, I was allowed the freedom and time to explore at such a deep level. Most of my time was spent learning how to model the loop heat pipe setup. This came through several different tools: SINDA/G (a thermal network analyzer for conduction and convection), Thermal Synthesizer System (radiation), and Thermal Desktop (general thermal analysis). With the aid of these programs, I was able to study and control very small details of the models: individual nodes, conductors, logic to command valves and variable properties, and libraries to replicate natural phenomenon such as phase change materials. Gradually, the model changed from a massive collection of nodes and conductors into a smaller, more effective, and refined model. With this model, I was able to learn more about the theoretical aspects of thermal engineering: when is free convection appropriate, how to distinguish between arithmetic or boundary nodes, what type of timesteps are required, and so on. Furthermore, it was a tool that I could use to analyze data that came from testing and to subsequently correlate the data in order to produce a model that could be used for various Mars environments. As each change was applied to the model and different answers would result, I was digging deeper and deeper into the problem.

Yet with all the power that the model presents the user, it is still limited. It only offers a single perspective, and this can be limiting if one is not careful. Equally as important as modeling is another crucial aspect of problem-solving: testing. At times, I was so deeply engrossed in the model that I lost sight of the end goal. But one quickly regains focus when in the lab. Each time I returned to the lab, I was able to see the actual hardware, with all of its beauty as well as limitations. A system can look perfect in a modeling sense, but the real world isn’t as forgiving. By testing and analyzing the results, I often find things I would never grasp if I dealt only with computer modeling. Parasitic heat leaks and insulation became very important issues, and it was much easier to arrive at some of the solutions with the first-hand experience in the lab. Different orientations had to be accounted for if the Rover was to land in an awkward position, and this was also accomplished in the lab. Additionally, different environments had to be accounted for, depending on where on Mars the Rover landed. Even helping the setup of the experiments revealed to me that certain things were too heavy or too delicate, or that the model could not possibly capture details like a complicated shape of a component. With the experimental side of problem-solving, I was able to see from a broader point of view.

Although these two facets of engineering seem to be at different poles, I realized how well they complement each other. Even more critical is the necessity of these two functions to be able to work hand in hand to come up with an accurate solution. “To go where no man has gone before”, whether it be physically to Mars or intellectually in our minds, we must be able to see both deeply into the technical side and laterally across different tasks. As I think back on what has been accomplished, I feel confident in saying that the mission was a success.